

Lesson 3.4: Momentum and Energy

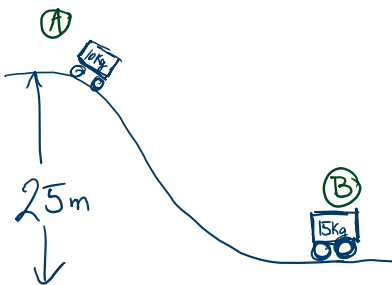
Unit 3: Momentum and Energy

Content Learning Standard: Problems involving both conservation of momentum and conservation of energy.

Types of collisions:

Collision Type	Momentum	Total Energy	Kinetic Energy	Objects Stick Together?
Elastic	Conserved	Conserved	Conserved	No
Inelastic	Conserved	Conserved	Not conserved	Sometimes
Perfectly Inelastic	Conserved	Conserved	Maximum E_k lost	Yes

Example 1 - A perfectly inelastic problem: A 10 kg cart, starting at rest, rolls down a hill with a vertical height of 25 m. At the bottom it collides with a stationary 15 kg cart. If the carts lock together, what is their velocity afterwards?



① Find $\vec{v}$ of 10 kg cart at bottom

$$E_A = E_A' \quad \leftarrow \text{means "prime" or final}$$

$$\cancel{E_{pA}} + \cancel{E_{kA}} = \cancel{E_{pB}} + E_{kB}'$$

$$\cancel{mgh_A} = \frac{1}{2} m \vec{v}_B'^2$$

$$v_B = \sqrt{2gh_A}$$

$$= \sqrt{2(9.8)(25)}$$

$$\vec{v}_B = 22.1 \text{ m/s}$$

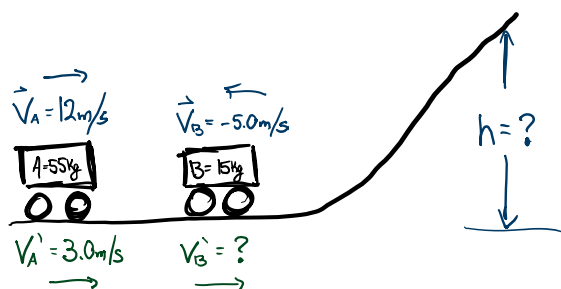
② Perfectly Inelastic Collision:

$$m_A v_A + \cancel{m_B v_B} = (m_A + m_B) v_{AB}$$

$$10(22.1) = (10 + 15) v_{AB}$$

$$v_{AB} = 8.85 \text{ m/s}$$

Example 2 – A perfectly elastic problem: Two carts collide elastically head on near the bottom of a hill. Cart A (55 kg) was travelling 12 m/s east while cart B (15 kg) was travelling 5.0 m/s west. After the collision, Cart A travels 3.0 m/s east. If Cart B heads east up the adjacent hill, what vertical height will it reach?



① Find $\vec{V}_B'$ w momentum

$$m_A V_A + m_B V_B = m_A V_A' + m_B V_B'$$

$$55(12) + 15(-5) = 55(3) + 15V_B'$$

$$V_B' = 28\text{ m/s}$$

② Find height w conservation of E.

$$\cancel{E_{pB}} + E_{kB} = E_{pB'} + \cancel{E_{kB'}}$$

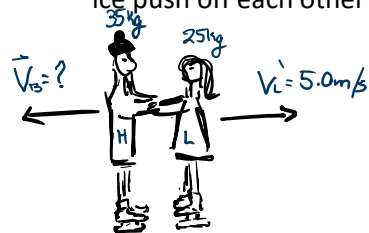
$$\cancel{\frac{1}{2} m_B V_B'^2} = m_B g h$$

$$h = \frac{V_B'^2}{2g}$$

$$h = \frac{(28)^2}{2(9.8)}$$

$$h = 40. \text{ m}$$

Example 3 – A problem that uses work: Two children (25 kg and 35 kg) standing together on frictionless ice push off each other such that the lighter travels 5.0 m/s. How much work was done?



① Conservation of momentum

$$\cancel{m_H V_H} + \cancel{m_L V_L} = m_H V_H' + m_L V_L'$$

$$\vec{V}_H = \frac{-m_L V_L'}{m_H}$$

$$\vec{V}_H = \frac{-25(5)}{35}$$

$$\vec{V}_H = -3.57\text{ m/s}$$

② Find Work

$$W = \Delta E_K$$

$$W = E_K' - \cancel{E_{K0}}$$

$$W = \frac{1}{2} m_H V_H'^2 + \frac{1}{2} m_L V_L'^2$$

$$W = \frac{1}{2} (25)(5)^2 + \frac{1}{2} (35)(-3.57)^2$$

$$W = 536\text{ J}$$